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EXPERIMENTS WITH DIFFERENT FORMS OF NITROGEN AT BORBHETTA.

BY

H. R. COOPER

PART I.

Consideration of results of manuring in earlier years.

In Quarterly Journal 1921, Pt. I., p. 11, is given an account of the commencement of this experiment.

The tea had been planted in 1916-17, left unplucked in 1917 and 1918, and then collar pruned.

Growth after collar pruning was irregular and poor. The yields obtained were very small and clearly gave no indication of the true initial yielding capacity of the plots. In early 1920 all but very few bushes had reached the plucking level, and the plots looked generally very level.

The yields of all plots were recorded from the beginning of the season (1920) until the end of May, after which three plots received bone meal only, while the remaining 15 plots were divided into five sets of three plots, each of which sets received a different nitrogenous manure in quantity to supply 30 lbs. per acre more nitrogen than the check plots received, and the same quantity of phosphoric acid as the check plots.

The check plots had yielded an average of 11 lbs. 3 ozs. per plot from March to May, and 46 lbs. 3 ozs. from June to November. That is, the June to November crop was 4.12 times the March to May crop. It was considered to be approximately true that if the other plots had remained unmanured, they also would have given 4.12 times as much crop from June to November as from March to May.

In these calculations an arithmetic error was made which was later pointed out by Petch in a review of the earlier reports on the experiments. (1)

(1) Petch, T. Manuring Experiments on Tea, *Tropical Agriculturist*, Colombo, Jan. 1925 (vol. 64, no. i, p. 4).

The following table gives the results calculated with this error corrected.

Table 1. *Results in first year of manuring* (1920).

	*Actual yield March to May.	lbs. Green leaf per acre.		
		Calculated yield if no manure had been applied June to Nov.	Actual yield after manuring June to November.	Increase due to Manuring June to November.
Nitrate of soda ...	594	2,446	2,689	234
Sulphate of ammonia ...	577	2,377	2,585	208
Green jungle	634	2,612	2,763	151
Oilcake	574	2,365	3,456	91
Sinews and skin ...	602	2,480	2,473	*Nil*

If the increases per cent. during June to November be calculated we get rough comparative efficiencies as below :—

Nitrate of soda	...	10 per cent.
Sulphate of ammonia	...	8½ ,, ,,
Green jungle	...	6 ,, ,,
Oilcake	...	4 ,, ,,
Sinews and skins	...	*nil*

These figures probably do represent fairly closely the increases to be expected in fairly good tea (the check plots gave leaf equal to 9½ mds. pucca tea per acre).

The quick acting manures naturally give much better results in the year of application, while the organic manures give less increase in the year of application because part of the organic nitrogen remains in the soil to come into action in later years.

* There were a very few bushes unplucked in 1920, because too weak. In these figures these have been allowed for. These bushes were so little inferior to the average that they were all plucked in 1921 when they were little inferior to the other bushes.

The sinews and skin proved so excessively slow as to give no increase at all in the first year.

It was noted that the sample of oilcake used had a very high percentage of oil, and that more normal samples would probably prove quicker in action.

Curves were published which confirmed the above rough estimates of efficiency.

It was pointed out that it was possible that the greater efficiency of the nitrate of soda compared to sulphate of ammonia was due to the fact that nitrate of soda supplied available potash while the sulphate of ammonia did not.

In Quarterly Journal 1924, Pt. II, p. 91, Wiles reported results from these same plots up to the end of 1923. He observed that the original good results from nitrate of soda had been well maintained, while the effect of sulphate of ammonia appeared poor.

Of the organic manures, both green manure and oilcake had yielded considerably better than the unmanured check plots, while the crushed sinews still failed to show any effect in 1922 as they had also in 1920, and showed only a small effect in 1923.

In 1921 all plots had remained unmanured. Wiles observed that the "corrected" yields from sulphate of ammonia, oilcake, and sinews were a little lower than those from the check plots indicating that there was no residual effect from the manures applied in the previous year. On the other hand the green manure showed a high residual value which was easily understood as this manure was added very late (July) in the previous year. Surprisingly enough a residual value also appeared from nitrate of soda.

Wiles reports only "corrected yields." The correction was applied in an attempt to allow for the initial differences in fertility between the various plots before manuring. As an index of the initial fertility of each plot Wiles used the yield obtained in 1920 from March to May, before manures were applied. These yields might have been good enough to serve to calculate approximate

results from manures applied in the same year, but there are certainly grave objections to the use of such figures to "correct" yields obtained three years afterwards.

Petch (1) in review of the above two reports pointed out that the method of obtaining the "corrected yields" was not published by Wiles nor were full details of the actual yields of each plot given so that other agriculturists interested had no means of judging the reliability of the correction used. In Petch's opinion it would have been better to have recorded two full seasons' yield from each plot without manure in order to obtain more accurate estimates of the effect of later manuring. He rightly attributes the failure to wait for such records to undue eagerness to "get results." All previous experiments with manures on tea had been on single plots of uneven tea, possibly of different earlier manuring history, with no record at all of initial yielding capacity. There was urgent need to obtain some more accurate idea of the results to be expected from different classes of manure, and it was hoped that the triplication of plots would render the results sufficiently accurate, after a certain length of time, to be of some value in practice.

The effect of the undue haste has undoubtedly been to reduce the accuracy of the results recorded, but the indications afforded are of very great value.

Full details of actual yield per plot up to the end of 1927 are now published for record. (See Table II.)

TABLE II.

Manure.	Plot No.	1920 manured May 29th		No manure 1921.	Manured 1922.	Manured 1923.	Manured 1924.	Manured 1925.	Manured 1926.	Manured 1927.
		March to May.	Total for year.							
Check plot ...	12	11 6	60 9	48 14	54 3¾	60 2¾	51 3	49 6	46 12	33 13¾
	6	9 15	52 7	43 14½	48 0¼	52 4½	46 3½	48 12½	43 4	37 2
	18	12 5	59 2	47 8½	50 14¼	54 1½	45 12½	46 8½	42 4½	39 15
	Total ...	33 10	172 2	140 5	153 2½	166 8¾	143 3	144 11	132 4½	110 14¾
Nitrate of soda ...	13	11 14	59 2	47 1½	57 8¾	70 14¾	60 4	61 12	54 6½	42 3¼
	5	9 7	58 14	48 15	57 11	73 8	65 4½	78 1	63 10½	60 11
	17	11 11	65 4	50 3	59 14¼	66 14	55 15	60 9	52 5½	47 15
	Total ...	33 0	183 4	146 4½	175 2½	211 5½	181 7½	200 6	170 6½	150 13¼
Sulphate of ammonia	4	11 14	62 8	48 4½	53 14¼	65 6	60 15½	64 13	61 3½	55 14½
	14	9 8	52 0	41 2½	48 10½	60 2¾	59 8½	72 9	61 12	56 15
	8	10 0	57 6	42 9	53 3	59 0¼	55 13	60 1½	55 11	57 1¾
	Total ...	31 6	171 14	132 0	155 11¾	184 10	176 5	197 7½	178 10½	169 15¼
Oilcake ...	3	10 15	57 11	48 14	60 3	67 0¾	62 2	67 15½	57 6½	50 2
	15	10 15	55 1	42 3	50 5¾	63 14¼	52 5½	61 9	50 2½	50 10½
	9	10 1	56 6	47 0	54 5¾	62 1	57 10	63 8½	53 7½	51 14¾
	Total ...	31 15	169 2	138 1	164 14½	193 0	172 1½	193 1	161 0½	152 11¼
Green manure ...	11	16 3	81 8	66 11½	63 8½	80 4½	80 4½	80 1½	69 7½	58 0¼
	7	8 8	48 11	46 12	51 4	58 3	50 10½	53 15	55 12½	52 7¼
	19	9 9	53 8	49 5½	57 0¼	65 9¼	63 1½	67 2	59 9	52 12¼
	Total ...	34 4	183 11	162 13	171 12½	204 1	194 0½	201 2½	184 13	163 3¾
Sinews and skin ...	2	10 6	45 14	46 9½	48 9¼	59 3¼	56 1½	62 2½	55 11½	47 7
	16	11 10	44 5	45 15½	50 15¾	56 7	47 15½	53 4½	54 5	43 5¾
	10	11 7	47 3	47 12½	50 13¾	58 7¾	56 9½	68 12	52 5	44 14½
	Total ...	33 7	170 13	140 5½	150 6¾	174 2	160 10½	174 3	162 5½	135 11¼

The plots were arranged according to the plan given :—

Plot No.	2	3	4	5	6	7	8	9	10
Manure	Sinews	Oilcake	Sulphate of ammonia	Nitrate of soda.	Check	Green manure.	Sulphate of ammonia.	Oilcake	Sinews

2′ path.

Plot No.	11	12	13	14	15	16	17	18	19
Manure	Green manure.	Check	Nitrate of soda.	Sulphate of ammonia	Oilcake	Sinews	Nitrate of soda.	Check	Green manure.

Drains 3½ ft. deep 9 ins. wide, running north and south, divided the plots.

The residual effects mentioned by Wiles can now be considered without reference to any correcting factor by considering the total crops actually taken in 1920 (with manure) and 1921 (without manure).

All crops were less in 1921 than in 1920 because the tea had been unpruned in 1920, and was pruned in 1921.

The check plots lost a total of	31 lbs.	13	ozs.
,, nitrate of soda plots lost a total of	36 ,,	15½	,,
,, sulphate of ammonia plots lost a total of	39 ,,	14	,,
,, oilcake plots lost a total of	31 ,,	1	oz.
,, green manure plots lost a total of	20 ,,	14	ozs.
,, sinews plots lost a total of	30 ,,	7½	,,

Such figures might be taken as indicating that while the residues of the green manure were still exerting a beneficial influence, the plots which had received nitrate of soda and sulphate of ammonia were showing a tendency to slump in the following year, but that the sinews and the oilcake were having about the same effect in each year.

Since, however, the nitrate of soda plots in 1920 had been better than most others it might be expected that they would show a drop (due to difference in pruning) more or less proportional to their original high yield even if effect had been the same in both years.

It may be more accurate, therefore, to consider the crops compared to the check plot in each year.

In that case we get the following figures for comparison.

	Yield as percentage of yield of check plot	
	1920	1921
Nitrate of soda	106½	104
Sulphate of ammonia	100	94
Oilcake	98	99
Green manure	107	116
Sinews	99	100

From these figures it appears that compared to the check plots oilcake and sinews had done just about as well in 1921 as in 1920, while the green manure plots were relatively better in 1921 than in 1920.

Both the soluble manures however did less well in 1921 than in 1920.

Whether actual losses of crop in 1921 as compared to 1920 are considered, or whether percentage drops compared to the check plot are considered, it is clear that—

(1) Both the oilcake and the sinews do about as well in 1921 and in 1920.

Having regard to the 1920 results considered alone, it is probable that the sinews showed no result in either year, and that a further addition in 1922 also showed no effect confirms this conclusion.

In the case of the oilcake the 1920 results alone indicated a small increase in crop in that year: it therefore must be assumed that the oilcake exercised a residual effect in 1921, about equal to the effect in the year of application. Application of oilcake in 1922 and following years showed much more rapid results. Different samples of oilcake undoubtedly do differ in rapidity of action. The sample used in 1920 was remarked upon for its high content of oil, and its slow but long continued action is ascribed to that cause.

(2) Nitrate of soda and sulphate of ammonia both showed less effect in 1921, than in the year of application 1920.

Of the two manures however sulphate of ammonia had made the bigger drop.

The nitrate of soda plots in 1921 were about 4 per cent. better than the check plots. In 1920 before manures were applied the yields from March to May indicate that they were then about 2 per cent. worse.

The sulphate of ammonia plots were about 6 per cent. worse than the check plots in 1921, and also in early 1920 before manures were applied. (See Table II.)

It appears then that while sulphate of ammonia exercises no residual effect in the year following that of application, there is some residual effect from nitrate of soda.

The original report of the 1920 results publishes curves showing quite clearly that in that year the effect of nitrate of soda lasted much longer than that of sulphate of ammonia.

It is well known that as far as the nitrogen is concerned nitrate of soda lasts less time than sulphate of ammonia, though the difference is not great. The residual effect of the nitrate of soda therefore must be ascribed to some cause other than the nature of its nitrogen content.

The original suggestion that the potash supplied by nitrate of soda was having some effect is the most probable explanation, and this is confirmed by the great improvement in the results from sulphate of ammonia when potash also was supplied in 1924 and following years to all plots.

Oilcake and green manure of course also supply some potash, so that these manures would not suffer greatly from deficiency of potash in the soil.

The green manure applied in 1920 showed a high residual effect in 1921. These green manure plots were about 2 per cent. better than the check plots in early 1920 before manures were applied and were 16 per cent. better in 1921. The fact that they

were only 13 per cent. better than the check plots in 1922 after a second application is more likely to be accounted for as showing an improvement over the unmanured yield of about 11 per cent. (due partly to the 1922 application and partly to the unexhausted residue of the 1920 application) rather than to an adverse effect from the 1922 application.

If that is so the green manure application of 1920 showed marked good effect during three seasons. It is considered to be quite likely that it would do so, not so much from the nitrogen applied as from the improvement in tilth from the large weight (3 tons per acre) of organic matter applied. It is possible however that more than 30 lbs. nitrogen were applied in this form. In 1920 the application consisted of mixed green stuff, mainly *futuka* (*melastoma spp.*) and the average nitrogen content was taken to be about 0.4 per cent. Sampling of such material is so difficult that it is quite possible that the actual average was higher.

In 1922 and following years the green stuff added was entirely boga medeloa cuttings, only green non-woody shoots being selected. This more uniform material is more easy to sample, and the estimate of 1 per cent. nitrogen is probably sufficiently near to its true average nitrogen content, though this too can be only approximate.

Whatever may be the reason there appears little doubt that the 1921 yields from the green manure were greatly increased on account of the 1920 manuring, and the 1921 yield therefore cannot be taken as an index of the yielding capacity of this plot unmanured.

In his review of the earlier reports Petch made the suggestion that the 1921 (unmanured) results might be used as a starting point from which to measure the results from manuring in the following years, in the cases of the soluble manures.

It will be seen from what has been written above that the 1921 yields cannot be considered in the case of nitrate of soda as equal to the yields which would have been obtained if no manure had been applied in 1920.

Examination of the figures in Table II however shows that up to the end of 1923 at least, all plots were increasing fairly regularly, and that the increases from manuring were, in the cases of the more readily available manures, roughly cumulative; that is, increases over the check plots from manuring with quick acting manures were about double in 1923 what they were in 1922. We may therefore take relative increases in 1922 over 1921, and in 1923 over 1922 as both indicating the effect of a single application of manure.

In the case of a manure which shows a residual effect, we may take it that the 1923 increase over 1922 shows the combined effects of the 1923 application and the residual effect of the 1922 application; so that if the increase in 1922 over 1921 is smaller than is due to one application of manure, the increase in 1923 over 1922 will be correspondingly bigger.

If, then, we take the average of the two increases, 1922 over 1921, and 1923 over 1922, we should obtain a fair estimate of the effect of a single dose of manure.

After 1923, results become irregular. Plots receiving the same treatment no longer maintain the same relative position among themselves. For example, of the three check plots, plot 18 was second best from 1920 to 1923, but became the worst in 1924. Of the nitrate of soda plots, plot 17 is the best in 1920, 1921, 1922 and 1923 but becomes the worst in 1924. By 1924 secondary effects would be making themselves felt; and, also, the young tea which had previously been healthy began to show diseases after the third dry spring in succession. After 1923, then, initial fertility records, even if obtainable, would be of slight value.

An additional reason for considering separately the results up to 1923, is that until that year the nitrogen was applied together with phosphoric acid only, while in 1924 and onwards potash also was supplied to all plots.

Results for 1922 and 1923 are shown in Table III. The increases for each plot are obtained by subtracting the yield for 1921 or 1922 from the yield of the same plot in the following year. The yield of each plot is given in Table II.

TABLE III.

Increases in crop due to earlier doses of manure.

MANURE.	Plot No.	Actual crop increase 1922 over 1921.		Actual crop increase 1923 over 1922.		Average annual increase.		Average annual increase of manured plot over adjoining check plot.		Average annual increase per plot due to manure.	
		lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.
Check	12	5	6	5	15	5	11	...		...	
	6	4	2	4	4	4	3	...			
	18	3	6	3	3	3	5	...			
Nitrate of soda	13	10	7	13	6	11	15	6	3	6	6
	5	8	12	15	4	12	0	7	13		
	17	9	12	6	15	8	6	5	1		
Sulphate of ammonia	4	5	10	11	8	8	9	2	14	4	5
	14	7	8	11	9	9	9	5	6		
	8	10	10	5	13	8	4	4	15		
Oilcake	3	11	5	6	14	9	2	3	7	4	13
	15	8	3	13	8	10	14	6	11		
	9	7	6	7	11	7	9	4	4		
Green manure	11	3	3 (decrease)	16	12	6	13	1	2	2	8
	7	4	8	6	15	5	12	1	9		
	19	7	1	8	9	8	2	4	13		
Sinews and skin	2	2	0	10	10	6	5	0	10	0	14
	16	5	0	5	7	5	4	1	1		
	10	3	1	7	10	4	6	1	1		

It will be observed that the check plots are increasing their yields (through increasing maturity) at somewhat different rates. Each manured plot is therefore considered with reference to the check plot adjoining it.

The manured plots increase definitely more than the check plots. The increases are irregular in the case of the green manure, but the agreement among the figures for any other three plots manured similarly is very fair; for example, each nitrate of soda plot increases more rapidly than the sulphate of ammonia plot adjoining it.

If the percentage increases are then calculated the figures should be approximately accurate. The following table shows the results obtained.

TABLE IV.

Showing increase in crop from single application of 30 lbs. nitrogen in different forms, applied together with phosphoric acid, but without potash.

MANURE.	Average annual yield per plot 1921 & 1923.		Average annual increase due to manuring.		Difference (probable yield if unmanured.)		Increase per cent. due to manuring for one year.
	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	
Nitrate of soda ...	64	7	6	6	58	1	11·0%
Sulphate of ammonia ...	56	12	4	5	52	7	8·2%
Oilcake	59	10	4	13	54	13	8·7%
Green manure ...	62	10	2	8	60	2	4·0%
Sinews and skin ...	54	1	...	14	53	3	1·6%
Check plots ...	53	5	...	...	53	5	......

It will be observed that the percentage increases calculated for 1922 and 1923 do not greatly differ from those calculated from the 1920 results except in the case of oilcake, which did much better in 1922 and 1923 than in 1920.

It will be interesting for planters to see what these figures mean in mds. tea per acre.

Manure.	Actual average crop 1922-1923.		Annual increase due to manuring (pucca tea.)	
	Mds.	Srs.	Mds.	Srs.
Nitrate of soda	10	3	1	0
Sulphate of ammonia	8	34	0	27
Oilcake	9	24	0	30
Green manure	9	31	0	16
Sinews and skin	8	18	0	5
Check plot...	8	13	......	

These probably are about the increases to be expected from a single dose of one of the particular manures. For rapidity of action nitrate of soda easily leads, but its big lead over sulphate of ammonia in these years is believed to be due partly to the potash which it supplies.

PART II.

Results from 1924 to 1927.

In these years 60 lbs. muriate of potash (giving 30 lbs. potash) per acre was applied to all plots in addition to the other manures.

Results in these later years, however, will be expected to differ from the earlier results for two other additional reasons :

One of these has already been referred to. In latter years plots under the same treatment began to change in their order of relative yield. Plots which had been relatively good, become relatively poor and *vice versa*. This is believed to be due to uneven attacks by disease.

The plots were collar-pruned in late 1918, unpruned in 1920, and have been top-pruned since. The most obvious disease is due to wood rotting fungi (*Poria spp.*) attacking at the collar pruning cut, and weakening the branches growing from the collar. There have been a few deaths of bushes from this cause and many dead branches. The west end of the strip of plots, in the neighbour-

hood of check plot 12, is badly attacked (though all plots are affected) hence the slumps in crop from this check plot and its neighbouring manured plots. The plots are so arranged however that no manured plot gets any advantage of position, so that it should still be fairly accurate to consider each manured plot with reference to its own check plot.

Any heavy pruning of plots under manuring experiment should in future be avoided as likely to introduce irregularity.

A further reason for separate consideration of the results in later years is that soils like these which are very similar mechanically would tend to become equal in crop as years went on, because the original differences would be due to differences in quantity of plant food originally present, and the originally richer soils become relatively more rapidly exhausted.

This exhaustion is made apparent by the appearance of the bushes on the check plots and by their falling yields between 1923 and 1925. At the end of 1925 the appearance was so poor that it was considered essential to pluck more lightly in order to keep the check plots going.

In 1926 and 1927 plucking left 8 ins. new wood (instead of 6 ins. as formerly) before tipping, after which plucking was to the *janum* or "fish leaf" in both cases. This applied to all plots. The effect of the lighter plucking has been to reduce all yields greatly, but there has been very marked improvement in the appearance of the bushes.

It will be observed that in 1927 there was very little difference in the yields from plots under the same treatment in the cases of the sulphate of ammonia and oilcake plots, and no great difference in the cases of the sinews plots, and the check plots. Even in the case of the green manure plots, plot 2 which was originally so greatly better than plots 10 and 16, is now not very greatly different. In the case of the nitrate of soda, plot 5 is very greatly better than plots 13 and 17, but as plot 5 was originally the worst plot of these three, it is clear that here also the

original yielding capacity of the plots is not affecting present yields to any great extent.

It is well known that an unmanured plot tends to fall in yield till it reaches a roughly constant yield varying up and down with the season; and that regularly manured plots also tend to settle down similarly but at a higher roughly constant yield.

These particular plots are on poor soil that should settle down in this manner fairly quickly. It can hardly be expected that they have yet settled down quite to the roughly constant yield but the later yields should give figures approaching this constant.

On account, then, of the diseases present, and on account of the general tendency for plots under the same treatment to level up, it will be more accurate to neglect any initial fertility records and to consider only the actual yields of each plot in the later years.

The following Table shows the yield of each set of three plots expressed as a percentage of the yield of the set of three unmanured check plots.

TABLE V.

	1920.	1921.	1922.	1923.	1924.	1925.	1926.	1927.
Nitrate of soda ...	106	104	114	127	127	137	128	136
Sulphate of ammonia ...	100	94	102	111	123	136	135	153
Oilcake ...	98	99	108	116	120	133	122	138
Green manure ...	107	116	113	122	136	140	149	147
Sinews ...	99	100	98	105	112	120	123	122
Check plot ...	100	100	100	100	100	100	100	100

Since there is considerable variation with season it may be fairest to consider the average of the last three years as the approximation to the constant difference between manured and unmanured yields. The regular additive increases from manuring

generally apparent up to 1925, do not continue generally in 1926, while the 1927 yields show generally much the same relative increase as in 1925.

We get then the following :—

TABLE VI.

Annual increase per cent. due to continued manure.

	1925.	1926.	1927.	Average.
Nitrate of soda ...	37	28	36	34
Sulphate of ammonia	36	35	53	41
Oilcake	33	22	38	31
Green manure	40	40	47	42
Sinews and skin	20	23	22	22

The actual crops obtained in mds. of tea per acre, are given for comparison in Table VII.

TABLE VII.

Crop increase from continued application of manure (manure first applied in 1920.)

	1925				1926				1927				Average annual increase	
	Yield		Increase.		Yield.		Increase.		Yield.		Increase.			
	Mds.	Srs.	Mds.	Srs.	Mds	Srs	Mds.	Srs	Mds.	Srs.	Mds.	Srs.	Mds.	Srs.
Check plots ..	7	21	... .		6	35	......		5	31	......		......	
Nitrate of soda ...	10	17	2	36	8	32	1	37	7	34	2	3	2	12
Sulphate of ammonia ...	10	7	2	26	9	11	2	16	8	33	3	2	2	28
Oilcake ...	10	2	2	21	8	35	2	0	7	38	2	7	2	9
Green manure ...	10	23	3	2	9	24	2	29	8	20	2	29	2	33
Sinews ...	8	30	1	9	8	18	1	13	7	2	1	11	1	11

These are very different results from those calculated for the immediate effect of a single dose.

While, then, very large increases are not to be expected from the addition of a single dose of manure even in quick-acting form, the cumulative effect of continuous manuring is seen to be very great. Even the sinews and skin, so difficult for the soil to decompose, do eventually give substantial results.

The effect of the green manure is probably somewhat exaggerated by the failure to take into account the fact that one of the green manure plots (No. 11) was so very much better than all the others originally. If the two plots (7 and 19) which were originally worse than all others, (though not much) be considered we get a total crop from plots 7 and 19 of 341 lbs. 10 ozs. in the 3 years, or an average *per* plot of 170 lbs. 13 ozs. Against this the check plots average only 129 lbs. 5 ozs. This represents an increase due to green manuring of about 32 per cent. In 1927 plot 7 is 41 per cent. above check plot 6, and plot 19, 33 per cent. above check plot 18. It is quite clear that the green manure has done very well.

In the case of the sulphate of ammonia plots, the results would appear still better if the poor relative initial yielding capacity were taken into account, so that there is no doubt about the eventual cumulative effect of this manure. Sulphate of ammonia is most unlikely to leave residues of nitrogen in the soil to accumulate fertility. As far as the nitrogen is concerned, it has been found in other countries only very slightly more lasting than nitrate of soda. Its big cumulative effect must be ascribed to some other cause. The following determinations of the acidities of each plot, made in 1927, probably provide the explanation.

		lbs. lime required to neutralize a million lbs. soil (Hopkins method).	pH. of soil (strength of acidity).
Check	6	483	5·6
	12	574	5·7
	18	434	5·7
	Mean ...	497	5·7
Sulphate of ammonia ...	4	651	5·2
	8	657	5·35
	14	735	5·15
	Mean ...	674	5·2
Nitrate of soda	5	525	5·8
	13	525	6·0
	17	413	6·0
	Mean ...	488	5·9
Oilcake	3	455	5·6
	9	273	5·8
	15	553	5·7
	Mean ...	427	5·7
Nervox	10	399	5·8
	16	420	5·75
	2	483	5·7
	Mean ...	434	5·7
Green manure	7	399	5·8
	11	339	5·75
	19	448	5·6
	Mean ...	415	5·7

It will be observed that the average acidity (lime requirement for neutralization) of the manured plots is always a little lower than that of the check plots, except in the case of the sulphate of ammonia plots which are very much more acid than the check plots.

The "pH" of the soil gives the "strength" of the acid which is present. It is measured on a scale such that a neutral soil

would have "pH"=7, and the *lower* the figure obtained, the *greater* the acidity. This test also shows the sulphate of ammonia plots as greatly the most acid. Nitrate of soda, although it shows less lowering of lime requirement than any other manure, shows the greatest lowering of strength of acidity (or greatest increase in pH).

The strength of acidity on the soils other than those manured with sulphate of ammonia, is lower than usually found on the very best tea soils. The increase in acidity due to the continued use of sulphate of ammonia is probably stimulating the growth of tea. As the use of sulphate of ammonia is continued further, it will be interesting to see whether a state of acidity is reached, eventually, which is harmful to the tea. It is at any rate clear that the increase of acidity due to 7 doses each of 150 lbs. sulphate of ammonia per acre has not yet done any harm on this moderately acid soil, so that the use of this manure for tea need cause no fear at all unless the soil is already very acid.

The nitrate of soda plots show, in 1927, very poor agreement, one of them (No. 5) is still yielding better than any of the other 17 plots, but the other two are now very poor.

All three plots, however, differ in appearance from all the others. This difference shows very markedly in the spring. At such times their appearance is much worse than that of the check plots. The new growth always comes away extremely slowly and branches die back annually. To some extent this is no doubt due to the absence of available nitrogen in the soil at that time, because a most marked change for the better occurs very soon after the manure application.

In addition to lack of residues of nitrogen in the spring, the nitrate of soda plots would be expected to suffer from a certain lack of tilth due to increasing deficiency of organic matter, which is not sufficiently maintained by the burial of the rather small

quantity of prunings. This would affect the sulphate of ammonia plots also, so that some other cause must be active.

The Bacteriologist suggests that the continual addition of the manure already as nitrate, has lowered the efficiency of the nitrifying bacteria by giving them nothing to do. In that case the soil would make poor use of ammonia produced from organic matter in the soil, and the suggestion offers a very probable explanation.

The oilcake has done very well, but after seven applications has not justified its very greatly higher price.

The sinews and skin also are expensive compared, for example, to sulphate of ammonia, and this very slow acting form of nitrogen has, at least so far, exhibited a very low efficiency.

All the slow acting manures do however produce a much better appearance of the plots in the spring, largely no doubt due to their organic matter content but probably also to the fact that residues of past manuring are then available to the plant as they are not in the case of the soluble artificials. This would indicate that earlier application would be advantageous. In these experiments from 1922 onwards, manures were added in April. March would probably be better.

In appearance the green manure plots always look better than the others. The gain in crop however has been slow, and even now the yields obtained are not as great as would be expected from the good appearance of the tea.

In this experiment, too, the green manure was not grown among the tea, but carried from outside the tea area, so that gains would be greater than when the green stuff is grown in the tea hindering its growth, so that although the green manure has done excellently at low cost, there are objections to its use as the sole source of nitrogen.

These experiments strongly indicate that the best and most economical method of manuring, would use soluble artificials as the main source of nitrogen but that these should be backed up as far as possible by green manures, or by cattle manure, to provide a store of slowly soluble nitrogen, and to maintain the soil's organic matter.

Summary and Conclusions.

The numerical accuracy of the results obtained from these experiments is not as great as could be desired, or as could be obtained by the use of a much larger number of plots for each treatment, after fully reliable previous records of unmanured yields.

They have however yielded very valuable information.

Results of a single application of any manure, even of a rapidly available one, are so small that they may be counter-balanced by other adverse factors, such as a poorer season, or even a slight change in the plucking system. Results after manuring therefore cannot always be expected, in practice, to exceed those of the previous year when unmanured.

Nor can crops always be expected to increase after fairly long continued manuring. The nitrate of soda plots, for example, gave less crop in 1926 than in 1922, after five years of manuring. Tea may deteriorate in spite of manuring, but it will deteriorate far less than if it had not been manured.

Among the various forms of nitrogen tried, there was considerable variation in action.

Nitrate of soda when applied with phosphoric acid was in earlier years very greatly the most efficient of all manures, but in later years the use of this manure as the sole source of nitrogen appears to lead to undesirable results.

If used together with some cheap form of organic matter it is probable that these undesirable results would not appear.

Sulphate of Ammonia when applied with phosphoric acid only, gave relatively poor results in earlier years. It appears probable that efficiency would have been greater if some potash had been used with it on this soil, and this is probably true of all sandy soils low in potash.

In later years its efficiency has been greater than that of all other manures tried. This is ascribed to its secondary effect in increasing the acidity of the soil.

This manure also should be backed up by the use of cheap forms of organic matter.

Oilcake. This manure in the first year gave a small increase only, which is ascribed to its high oil content. Later application of less oily samples did much better. Generally speaking it has done very well indeed with regard both to early effect, and to the final effect after long continued application. This manure supplies organic nitrogen in relatively available form suitable for all soils except very heavy ones. It would be more widely used if *it* were cheaper.

Sinews and skin. This very slow acting form of nitrogen has done relatively poorly. It showed no effect at all until three applications had been made, and after seven applications has done much wrose than any other manure tried.

Green Manure. This material proved relatively slow in action, but the final effect after several applications proved very good indeed, and has been obtained at a very low price. The slowness of the effect however, makes it desirable to use material of this kind in conjunction with a soluble inorganic manure.

APPENDIX.

Estimates of Profit from Manuring.

It does not follow that the manure which shows most profit in these particular experiments would be the best everywhere. Even in these experiments, in fact, it appears that a combination of different forms of nitrogen would have done better than any one alone.

Estimates of the profits shown are interesting rather to show what are the profits likely to be obtainable from successful light manuring, and to illustrate the manner in which profits would vary as the cost and efficiency of the manuring vary, and as the price obtained for the tea varies.

The check plots received 30 lbs. phosphoric acid, and later 30 lbs. potash annually, the manured plots received in addition 30 lbs. nitrogen, the prosphoric acid content (if any) of the nitrogenous manure being neglected. The results calculated therefore have actually been obtained from the use of the nitrogenous manure alone: but, as the potash and phosphoric acid used alone probably gave very little increased crop while they did increase the efficiency of the nitrogen used, the cost of the manure used will for comparison be considered as that necessary to supply 30 lbs. each of nitrogen, phosphoric acid, and of potash (when applied) annually.

From 1920 to 1923 no potash was applied.

The following mixtures may be taken as producing the effect measured.

		Providing lbs. per acre.		Present price per ton in Calcutta.	Cost per acre
		Nitrogen.	Phosphoric acid.		
				Rs. as.	Rs. as
Nitrate of soda ...	200 lbs.	30	...	165 0	14 12
Superphosphate ...	150 ,,	...	30	75 0	5 0
Freight on ...	350 ,,	...	...	35 0	5 7
Carting ...	...	...	...	3 8	0 9
Application ...	...	...	...	...	2 0
				TOTAL Rs.	27 12
Sulphate of ammonia ..	150 lbs.	30	...	160 0	10 11
Superphosphate ...	150 ,,	...	30	75 0	5 0
Freight on	300 ,,	...	...	...	4 11
Carting	...	...	...	...	0 8
Application ...	...	...	...	...	2 0
				TOTAL Rs	22 14
Oilcake	667 lbs.	30	12	77 0	22 15
Superphosphate ...	90 ,,	...	13	75 0	3 0
Freight on ...	90 ,,	...	..	...	1 6
Carting ...	757 ,,	...	...	5 4	1 12
Application ...	...	...	...	...	3 0
				TOTAL Rs	32 1
Sinews and skin ...	300 lbs.	30	12	110 0	14 12
Superphosphate ...	90 ,,	...	18	75 0	3 0
Freight on ...	390 ,,	...	...	35 0	6 1
Carting ...	...	...	...	...	0 10
Application ...	...	...	...	...	2 0
				TOTAL Rs.	26 7
Green manure—					
Boga medeloa ...	3,000 lbs.	30	8 ?	(labour only)	7 0°
Superphosphate ...	110 ,,	...	22	...	3 11
Freight on ...	110 ,,	..	...	...	1 11
Carting ...	110 ,,	...	...	...	0 3
Application ...	110 ,,	...	...	...	2 0
				TOTAL Rs.	14 9

° It took 3 men about 2 hours to lop green branches, cut conveniently for even spreading, carry about 200 yards, and spread on 3/50 acre.

The Boga medeloa has been going for many years so that the cost of growing it on waste land is very little.

The extra crop due to manuring still has to be plucked, manufactured, put in boxes, and carried to the sale room. Such harvesting and marketing costs must therefore be taken into account when considering the cost of the increased crop: although such costs as cultivation and overhead charges generally would be the same for the larger crop as for the smaller one.

These harvesting and marketing costs have been estimated by several experienced planters to be about Rs. 20 per maund as a rough average. This figure will serve for use in illustrating the principles involved although it would vary on different gardens. Taking the figures obtained for crop increase from these experiments, the profits obtained are shown in the following table, No. VIII and No. IX.

TABLE VIII.

Estimated profits from a single dose of 30 lbs. nitrogen.

	Increased crop.	Cost of manuring.	Harvesting and marketing costs.	Total cost of increase.	Cost of increase per md.	Lowest price per lb. of tea at which manure pays expenses.	Profit per acre when price of tea is— 9 as.	12 as.	Re. 1.
	Md. srs.	Rs. as.	Rs. as.	Rs. as.	Rs. as.	As. p.	Rs. as.	Rs. as.	Rs. as.
Nitrate of soda	1 0	27 12	20 0	47 12	47 12	9 7	2 12 (loss)	12 4	32 4
Sulphate of ammonia	0 27	22 14	13 8	36 6	53 14	10 6	6 0 (loss)	4 2	17 10
Oilcake	0 30	32 1	15 0	47 12	63 11	12 12	14 0 (loss)	0 4 (loss)	12 4
Green manure	0 16	14 9	8 0	22 9	56 6½	11 5	4 9 (loss)	1 7	9 7
Sinews and skin	0 5	26 7	2 8	28 15	231 8	2 14 4	23 5 (loss)	19 7 (loss)	18 15 (loss)

It will be observed that single doses even of the most rapid and efficient manures pay little or no profit unless tea prices are good.

TABLE IX.

Estimate of steady annual profits from continuous annual manuring.

	Annual increased crop.	° Cost of manuring.	Harvesting and marketing costs at Rs. 20 per md.	Total annual cost of increase.	Cost of increase per md. of tea.	Lowest price per lb. of tea at which manuring pays expenses.	Annual profit per acre when price of tea is— 9 as.	12 as.	Re. 1.
	Mds. srs.	Rs. as.	Rs. as.	Rs. as.	Rs. as.	Rs. as.	Rs. as.	Rs. as.	Rs. as.
Nitrate of soda	2 12	31 6	46 0	77 6	33 16	6 9	26 2	60 10	106 10
Sulphate of ammonia ...	2 28	26 8	54 0	80 8	29 13	5 11	41 0	81 8	135 8
Oilcake	2 9	35 11	44 8	80 3	36 1	7 3	19 15	53 5	97 13
Green manure	2 33	18 3	56 8	74 11	26 6	5 3	52 7	94 13	151 5
Sinews and skin	1 11	30 1	25 8	55 9	43 9	8 9	1 13	20 15	46 7

° In 1924 and following years 60 lbs. muriate of potash per acre, costing Rs. 3-10, was applied to all plots.

It will be observed that the average gain from the fifth to the seventh year of manuring has been sufficient to pay a fair profit even when tea prices are low except in the case of the sinews. When tea prices are fair the profit is considerable, while when tea stands at a high price the profit from manuring is very good indeed.

The alternative to manuring is soil deterioration which in many soils may lead to such small crops that their sale does not repay the unavoidable overhead costs.

RED SPIDER.

BY

E. A. ANDREWS.

The first published reference to red spider of any importance is contained in a brochure entitled "Report on the Tea-Mite and "the Tea-Bug of Assam," by J. Wood-Mason, published in 1884. Wood-Mason was the first to give a recognisable description of the pest, gave to the mite its scientific name of *Tetranychus bioculatus*, and published illustrations of the male and female mites which gave a sufficiently adequate idea of the appearance of the mite for the purpose of identification. Wood-Mason's work was incorporated by E. C. Cotes in "An Account of the Insects and Mites which attack the Tea Plant in India," published in 1895, in which a small woodcut, showing the male and female, appears to have been reproduced from Wood-Mason's figures. Finally, an account of the mite and its depredations, based on Wood-Mason's work, appeared in "Pests and Blights of the Tea-Plant," by Sir George Watt, of which the second edition revised by Mann appeared in 1902. Beyond this, subsequent published notes on the mite are confined to accounts of attempts at control, and as the above publications are all out of print, there is at the present time no account of the nature and activities of this pest of tea, readily accessible to tea planters.

In view of the fact that, of late, numerous requests for information on this matter have been received, it has been thought desirable to publish a short note on some of the salient points connected with the bionomics and control of red spider.

Red spider is not an insect, but is more closely related to the spiders, and belongs to the group, known as *Acarina*, which contains such well-known organisms as the cheese-mite and the various ticks. In structure, therefore, and in its mode of development, red spider differs from the insects, though in its habits, depredations and relationships it shows many similarities.

Red spider lives, in North-East India, on the upper surface of the leaf of the tea plant, in colonies which vary according to circumstances from a few individuals to as many as can be accommodated on the leaf. These colonies consist of five forms, all of which are generally present at the same time—adult males and females, and eggs, larvae, and nymphs—though colonies consisting of a few individuals only are usually found to be composed mainly of adults and perhaps a few eggs.

To the naked eye a colony of red spiders has the appearance of a mass of tiny red specks, which are the living mites and eggs, and of tiny white specks, which are the skins cast in moulting, and the empty egg-shells. Under a comparatively low magnification, however, it is possible to distinguish between the forms mentioned above.

The adult female is a fat, globular organism, about 1/25 inch long, having a body more or less the shape of an ostrich egg, with the longer diameter from head to tail. At the front end is a flat bilobed rostrum (a prolongation of the head at the end of which is a slit-like mouth), and there are four pairs of legs, two of which project forward, and two behind, when the insect is at rest. The body is divided into six sections by transverse divisions, in a manner somewhat similar to the segmentation of an insect. The first section, which forms part of the head, and bears on each side a pair of tiny eyes (whence the name *bioculatus*), and the last section, are red. The intermediate sections vary from dark blood-red to reddish-chocolate. The rostrum and legs are of a yellowish-orange ground colour, marked with red. Along the back are four rows of fairly long, white, stiff hairs, directed upwards and backwards. These appear to serve the purpose of brushing aside the web, referred to later, as the mite moves through it. The legs are also provided with hairs, and at the extremity of each there is a curved claw, apposed to a series of short stiff knobbed bristles, which appear to be adapted to enable the mite to cling to the strands of the web. The mite is provided with retractile needle-like mouth-parts, with which it pierces the tissues of the plant, and, pressing the lips of the

mouth-opening against the surface of the leaf, sucks out the juices of the plant. This applies to all the active stages.

The male is smaller than the female, being about 1/30 inch long, and is easily distinguished by being pyriform in shape, rounded in front and bluntly pointed behind. It is divided into seven divisions, with the same arrangement of legs and eyes as the female, and is coloured similarly. It is also provided with similar dorsal bristles, and the legs and feet are similar in construction.

The egg is very large in size for the mite, being about 1/100 inch in diameter. It is spherical, and rests on the surface of the leaf. From its upper pole projects a hair-like extension of the shell which bends back to form a hook. This hook attaches it to the web, so that it is attached to the leaf by the base, and to the web by the hook, and is thus very firmly fixed. The colour varies in colour from orange yellow to deep red, but the sequence of changes has not been properly followed. A favourite place for depositing the eggs is alongside the ribs of the leaf, but they may be found anywhere on the upper surface.

The young mite, when it emerges as the larva, is ovoid in form, globular like the adult female, and orange-yellow in colour. It is about 1/100 inch in length. The number of legs, however, is only six—three on each side. As it becomes older it gradually turns pink and then red.

The nymph bears a great resemblance to the adult female in every way, and possesses eight legs arranged in a similar manner. It varies in size from 1/40 to 1/30 inch.

The development of the mite is simple. When the larva is ready to emerge it exerts pressure on the shell of egg, which splits along a horizontal line at the equator, and the mite pushes itself out sideways. It is active from the first, and immediately begins to feed. After a time it moults and gives rise to the eight-legged nymph. This in turn moults to form the adult. Moulting is very simple. The mite fixes itself firmly to the web on which it sits, and, gradually, the joints of the legs become

separated from the outer skin. At the same time, by the admission of air between the body and the outer skin, the latter becomes visible as a glistening white covering. This appearance gradually extends all over the body. At length the mite, by struggling, pushes the two hind pairs of legs out on either side, the outer skin rupturing to let them through. Having obtained a purchase with the two pairs of legs, the mite struggles until the outer skin begins to split upwards from one side, and tries to force the body out sideways at that side. Eventually, as the outer skin splits further round, this is accomplished, and the mite emerges. The time passed in the different stages is difficult to determine, as all observations have to be made under a microscope, and the mites are so active, and disappear so rapidly from the microscope field, that it is impossible to keep an eye on one the whole time. It is estimated, however, that the insect becomes adult in five days. A great feature of the life history of the red spider is that no time is wasted. After emergence from the egg, and after moulting to the nymph, the mite begins to feed immediately, while copulation begins the first possible moment after the emergence of the adults. So much is this the case that, about half-an-hour before a female is ready to emerge, the males cluster round, a number—generally four—embracing the moulting female, one in front, one behind, and one on each side. Before she is out of the outer skin the struggle for possession begins, and directly the first male has been admitted the rest are struggling to take his place. This goes on for some time. As soon as one male has served the female another is admitted, and as many as fourteen have been observed to have been admitted in unbroken succession. The female then immediately commences to feed, but after feeding for a few minutes is again ready to admit the males. Similarly, one male seems to be able to serve a long succession of females one after the other. The above observation refers to a period at which red spider is actively developing. At other times the mites may be watched for long periods without being seen to do other than feed. Eggs are laid the same day, and so far as can be observed the females live for a long time, depositing eggs singly at intervals.

It has been stated above that a web is formed on the leaf. This web is so fine that it can only be seen occasionally, and is even then difficult to make out. It has always been stated that the web is above the mites, and that they run about beneath it. This is so, but there is no doubt that there are several layers of web at different levels, and that the mites, although they can undoubtedly run on the leaf, run, where there is a colony, on the strands of the web. When it is possible to watch one from the side when it is feeding, it can be clearly seen that the feet do not touch the leaf, and that the tip of the rostrum is at a lower level than the claws of the feet. Thus, when feeding, the front of the body is down, the hind end up. The mites may also be seen to run over and beneath each other without any apparent collision, and it seems apparent that the leaf, wherever there is a flourishing colony, is covered with a tangled mass of very fine web, in and about which the mites move. This web undoubtedly acts as a great protection from rain, wind, etc., and must greatly impede the action of spray fluids and dusting powders, in fact both have been applied, and subsequent examination under a microscope has revealed the fact that the drops and grains lay on top of the web, while the mites ran beneath them without being affected.

The method of feeding has already been mentioned. When the mite has finished sucking an irregular pale green blotch is left on the leaf. This gradually turns yellowish-brown, and then reddish-brown, and as the blotches increase in number and coalesce the whole leaf takes on the reddish-brown appearance so characteristic of an attack of the pest. As the affected tissue dries out it contracts, so that the edges of the leaf tend to be pulled together, and as this tension is on the upper surface the sides of the leaf curl upwards. Eventually the leaves drop off. Red spider, in the first instance, always attacks the old leaves, and only affects the buds and young leaves in extreme cases. In cases of light attack the leaves do not drop off, and, as the leaves never regain their normal appearance, but retain the reddish-brown colour caused by red spider attack, it often happens that, to the casual eye, red spider appears to hang on longer where

attack has really been lighter. This was particularly noticeable in the Duars in 1927. As a final result of the extraction of sap and tissue by the mite from the body of the leaf the underside takes on a mottled appearance.

The mites spread about the bush by running along the stems and branches from leaf to leaf, and where bushes are touching they will spread from bush to bush in the same way. They also pass from bush to bush *via* the trunk and the intervening ground, They may, however, traverse long distances when they are seized with a definite urge to migrate. To do this the mite sits at the tip of a leaf or on a leaf at the top of the bush, and spins a long silk thread. When this is of sufficient length for its buoyance in the air to support the mite the latter lets itself go, and is carried along by the breeze. On one occasion a red spider floated in this manner through the window and landed on a table at which the writer was working. The mites are also carried about by cattle and other animals, and on the clothes of coolies and of course many are carried about in the plucking baskets.

The question as to where the red spiders go when their work is not evidenced on the bushes is one that is often asked. It is difficult to say where they do not go. Their habit of migration on a silken thread allows of their being carried almost anywhere. There are times, such as when the tea is heavy-pruned, when they may enter into a kind of hibernating stage in the crevices of the bark of the stems, or in the soil, but wherever there are leaves in the tea they may be found on an odd leaf here and there at any time of year. The fish leaves, or jhannums, are favourite places, and it is seldom that a few cannot be found, living in a very sheltered situation at the base of a jhannum leaf, somewhere in a section. Many mites of a similar description are known to hibernate in crevices of bark, in the soil, in masses of rubbish, and similar places. In the case of an organism so minute negative evidence is very unsatisfactory. The mites have been found in crevices of the bark, but have not yet, by the writer, been found in the soil. Eggs have never been found in either situation. In face of the fact, however, that treatment of the bark of pruned tea

has on many occasions resulted in an apparent check on red spider, a temporary hibernation, at any rate, must be supposed to take place for the present, though the fact that they may be active at any time of year shows that such hibernation may not even be usual.

The length of time for which an adult may live is a fact that is very difficult to determine. The writer believes, though without definite proof, that it is considerable. They may continue to copulate for days, during which period mating may have occurred scores, if not hundreds, of times, and one can only believe that if this be necessary—and in Nature there is a reason for everything—egg-laying must go on for a very long time. If the mites do die a natural death they leave the colony to do so. Dead mites are found on the leaves, but they always have the appearance of having been killed by some external agency, either enemy or accident.

Red spiders do have enemies, and several have been observed, which, however, are already to be found throughout the tea districts. There are two lady-bird beetles. One is a moderately large one, yellow to orange in colour, with six angulated bands across the back, three on each wing-cover, known as *Chilomenes sexmaculatus*. The other is very small, shining black in colour, a species of *Scymnus*. There is also a Staphylinid beetle, first recorded by Mr. Gyles Mackrell in Sylhet, and the writer has observed the larva of a Staphylinid beetle to suck the eggs. The larva of a lace-wing fly also feeds on red spider.

Red spider feeds on a variety of plants besides tea. On the tea gardens it may sometimes be found on Boga medeloa (*Tephrosia candida*) and on *Derris robusta*, as well as on many jungle plants. Peal recorded that he found it on the kadam tree (*Anthocephalus cadamba*), and the writer has found it even on roses. So far as the tea gardens are concerned, however, it may be taken for granted that wherever tea is opened up there will be some jungle plant with red spider on it, and that forever after the presence of alternative food plants is quite unnecessary for its deve-

lopment. Moreover, the tea plant may be attacked at any stage in its growth, from the time at which it has thrown out two or three leaves in the nursery.

It will thus be seen that the mite is to be found on every garden in tea, that it can undergo the whole of its life-cycle on the tea bush, and that it may attain a high degree of activity at any time of year. Any one who travelled from Dam Dim to Madarihat on the Bengal-Duars Railway in May 1927 would agree as to the ubiquitous nature of the pest without a second thought, but under ordinary circumstances the question naturally arises as to why damage should be experienced in one place and not in another, and, in the same place, at one time and not at another.

When a complete answer can be given to that question we shall be able to put "*Finis*" to the history of red spider as a pest.

In the meantime, however, observations are being made, and data collected, which afford indications that the incidence of red spider, as a pest, is almost entirely controlled by the condition of the plant. In Diagram 1 will be found a plan of the area of tea, at Tocklai, known as the clearance, showing the distribution of red spider and the intensity of red spider damage, bush by bush, in 1925. Diagram 2 shows the same thing for 1926. Similar observations were made in 1927 and 1928, but the diagrams are not reproduced on account of the cost of printing. Each separate square represents a tea bush, and the intensity of damage is shown by the depth of the red shading. The lightest red shade means that the red appearance due to red spider was to be found somewhere on the bush—it may have been only on one leaf—but little damage was being done. The deepest red shading means that the bush was, to all intents and purposes, shut up at the time. The dots indicate bushes on which the mites were found, but no trace of damage occurred, while on the unmarked bushes it was impossible to find the mites. The first point that will occur to one who studies these diagrams is the fact that the distribution of damage does not correspond with the distribution of the mite. A further point, not evident on the diagrams, is that,

while the bushes with the deepest red shade—shut up—succumbed during a week-end, that is, in two or three days, mites were to be found on the bushes marked with a dot throughout April and May, but no trace of damage accrued. Why should this be? There is no apparent reason so far as the mite is concerned. Climatic conditions were uniform throughout the area, which is only about 3 acres in all, and it is not to be supposed that the mites on the dotted bushes were any different from those on the others. The only possible explanation is to be found in a difference in the condition of the plants.

A comparison of Diagrams 1 and 2 shows the effect of a modification of the condition of the plants, produced by cultural operations, on the distribution of damage. In the case of the plots of tea under discussion one half of each plot is pruned every year, the other half every other year. In 1925 the whole area was pruned, so that the annually pruned bushes were, that year, the higher. In 1926 only the annually-pruned halves were pruned. The effect of leaving the tea unpruned is at once apparent, for, while 1926 was a year in which red spider attack was less intense (only 1 bush was shut up against 84 in 1925), and the annually-pruned halves, on the whole, suffered less, every unpruned half suffered much more than in 1925. Thus the result of leaving the tea unpruned was to conduce to more severe damage by red spider in a year in which, other things being equal, damage was generally less severe. These results are confirmed by the subsequent observations made in 1927 and 1928, as is shown by the records of the percentage intensity of attack in the various plots, given below.

Pruned Annually.

Variety of Plant.	1925 Pruned.	1926 Pruned.	1927 Pruned.	1928 Pruned.
China	47·2	2·8	1·4	0·4
Panighat	9·4	0·1	0·7	0·9
Singlo	4·5	1·0	0·4	1·4
Kharikatia	0·4	0·1	0·1	0·2
Kalline	0·2	0·1	0·5	0·8
Betjan	0·1	1·2	0·0	0·3

Pruned Biennially.

Variety of Plant.	1925 Pruned.	1926 Unpruned	1927 Pruned	1928 Unpruned.
China ...	0·3	6·5	0·3	10·9
Panighat ...	0·0	11·2	0·1	0·4
Singlo ...	0·1	13·4	0·2	12·4
Kharikatia ...	0·3	27·9	0·4	26·1
Kalline ...	0·8	7·5	0·0	44·9
Betjan ...	1·2	48·0	0·0	13·4

The reason for the fact of the China being so much worse than the other plots in 1925, the Betjan in 1926, and the Kalline in 1928, is not apparent. The observations rule out the presence or absence of the mite as a deciding factor. The effect of leaving the tea unpruned is, however, marked in a most decided manner.

Throughout the whole series of observations the plots in the Western half of the area tend to suffer more than those in the Eastern half. Much of the top soil was pulled down from the Western to the Eastern half when the plots were originally levelled, and for a few years the Western half suffered from the water-logging effect of borrow-pits between the tea and the Government road, and these facts may have something to do with it.

A second series of observations, made during the two years 1925 and 1926 (and subsequently) shows the effect of another cultural operation in bringing about liability to damage. Diagrams 3 and 4 represent four small plots, again on Tocklai, on which, previous to 1925, red spider damage had been unknown. At the beginning of 1925 the Manipuri plot was covered with Pabco-Thermogen. One result was severe damage by red spider. The percentage intensity of attack in the Manipuri plot was 24.9, against *nil* in the other three plots. At the end of 1925 the Pabco-Thermogen was taken up, and cultivation brought into line with the other plots, with the result that in 1926 there was no damage by red spider, nor has there been since, though mites are always to be found in the plots. Thus, at the same time that damage was being increased in one set of plots, it was being removed in another set of plots, the only variable factor being in each case one cultural operation.

Reverting to the figures for the plots in the clearance, it will be observed that in only one year did any of the pruned plots suffer severely, in 1925. That year was a year of more intense attack than the other three. The meteorological records show that during the early part of 1925 climatic conditions fluctuated more than usual, swinging across-from dry and hot to wet and cold and back again, while in the other three years conditions, though different each year, were more uniform in the one year. There are many indications that tea undergoes a reaction each time there is a change in environmental conditions, and takes time to adapt itself. Thus, alongside the clearance is a small area of young tea, now 20 months old from seed. Last year this tea suffered from red spider in the cold weather, the climax being at the end of January, while the clearance, alongside, was free. In May, when the clearance was badly affected, the young plants were free. At the time of writing, again (October), there are indications that the mites are becoming active on the young tea, but none on the older tea. It would appear that the young shallow-rooted plants are affected by the change to cold weather conditions almost at once, while the older plants take longer. In the case of the older tea there is another disturbing factor in operation in April—May, in that plucking has commenced. Observations in the field lead one to believe that the period just after "tipping" is a critical time for the tea-bush. It has been pruned, receiving a shock by that. After a time growth has commenced and increased until the bush becomes settled, one might say, into a growing condition. Then it is suddenly checked by "tipping," and further adaptation becomes necessary. We have as yet, however, no accurate experimental data on this matter, though convinced that it appears to have much to do with the onset of damage by red spider.

A further series of observations, on the connection between vitality of plant and red spider, was recorded in a recent number (Part II for 1928) of this Journal, and the records do not need to be repeated here. Suffice it to say in that series of observations

it is conclusively shown that damage by the mite was definitely correlated with the condition (in this case the vitality as measured by growth) of the plants.

An account of further observations in connection with the incidence of red spider was given in the last number of this Journal (Part III for 1928). It is therefore unnecessary to go into these in detail in this place, but it may be noted that those observations showed that all pruning systems which tend to bring about the retention of poor and old wood in the bushes for a shorter or longer period cause an increase in the prevalence of red spider, and careful pruning, cleaning out, and avoidance of unpruned tea, are all showing a beneficial effect in that series of plots.

The above observations will be continued and extended, and as information accumulates with regard to the changes in the soil and bush which accompany these various relationships rational methods of complete control will evolve. In the meantime unpruned tea, which has always been condemned, except where labour conditions compel it, by the Entomological branch of the Department, and is now falling into disfavour with many who were formerly among its most ardent advocates, should be avoided as much as possible on areas subject to red spider. Such areas should also be regularly cleaned out, not overdoing it, but removing useless wood and twigs each year. It should always be remembered that in agriculture things work to an optimum, not to a maximum. A swing of the pendulum too far in either direction is the reverse of beneficial. To take out only useless and superfluous shoots each year is far better than to overdo it one year, and not do it the next. Where soils are such that panning takes place readily, it will often be found that the attacks of red spider which sometimes come on in August, especially when on young tea, are due to this cause. At such times a trench hoe down the lines has been found of benefit.

It is possible to destroy numbers of the insects by means of insecticides. It is obviously sane to conclude that where, say,

95 per cent. of the mites have been destroyed, and are therefore not present to attack the bush, benefit must accrue, but we have as yet evolved no method of measuring it. Leaf returns have not yet been such as to allow of correlation with the percentage of mites killed, and in all cases, so far, it has been observed that the unsprayed bushes appeared to come through simultaneously with the sprayed bushes. The web on the leaves is a great protection against the older methods such as mudding and sulphuring, and to a certain extent against the more recent methods of applying spray fluids, and there is no doubt that much depends on the extent to which this web is broken down. Mudding still has its adherents, though Wood-Mason, in 1884, cited a case in which tea was submerged by a flood, and every leaf entirely covered with a deposit of mud, yet in two days' time, when the mud had cracked with the sun, the mites were found to be active beneath it. Powdered sulphur is also claimed by some to be effective. It certainly has an insecticidal value against the mite, and in experiments carried out by this branch of the Department, more or less under laboratory conditions, 100 per cent. of the mites were killed by the use of sulphur. At the same time, much of its efficacy depends on the extent of protection afforded by the web, and it seems possible that the known advantage of applying it while the dew is still on the bushes may be due to the weight of the water pressing down the web, which certainly bends without breaking under a surprisingly strong pressure, thus allowing a closer contact between the particles of sulphur and the mites.

The more modern spray fluids, are, however, more reliable on the whole, and most of the proprietary insecticides now on the market will kill the mite, though in most cases the fact that their efficiency in the field is mainly determined by the thoroughness of application, to ensure which demands much time, labour, and money, plus the fact that in most cases they are too expensive, puts them out of court. Lime-sulphur, though demanding the same thoroughness of application, has the advantage, first, of being cheap, and second, of being of value against most leaf and stem diseases as well, and is therefore generally

TOCKLAI CLEARANCE Dist

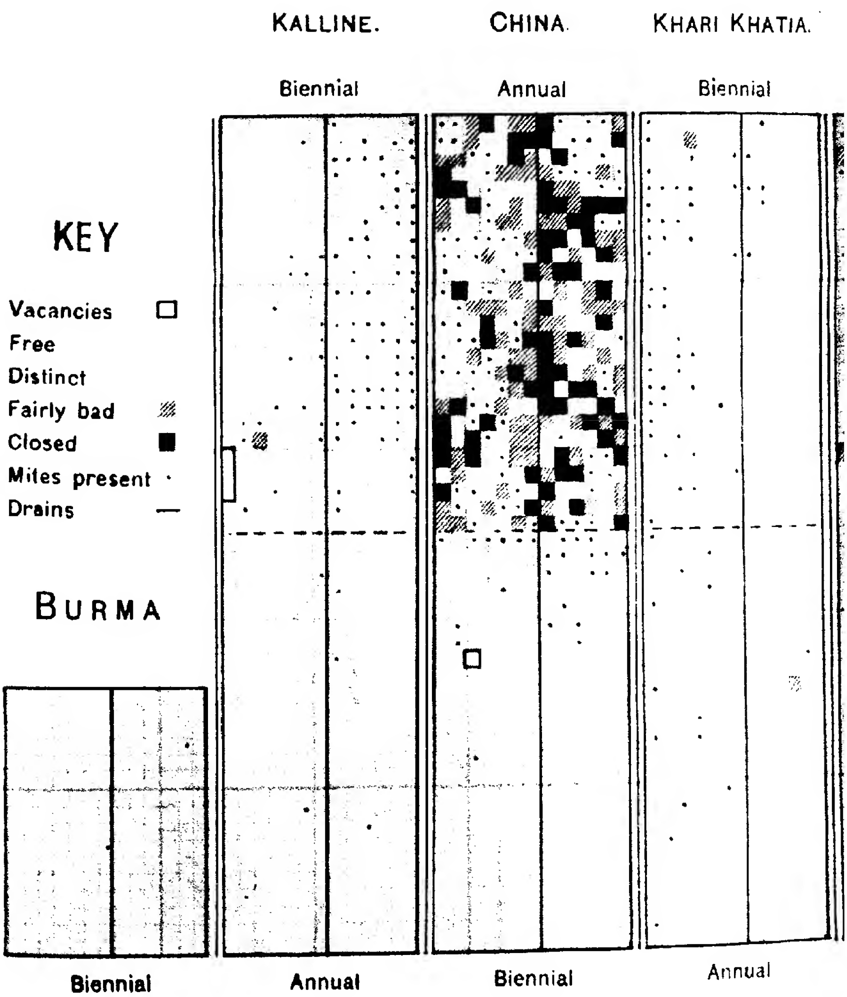

DIAGRAM 1

TOCKLAI CLEARANCE – Dist

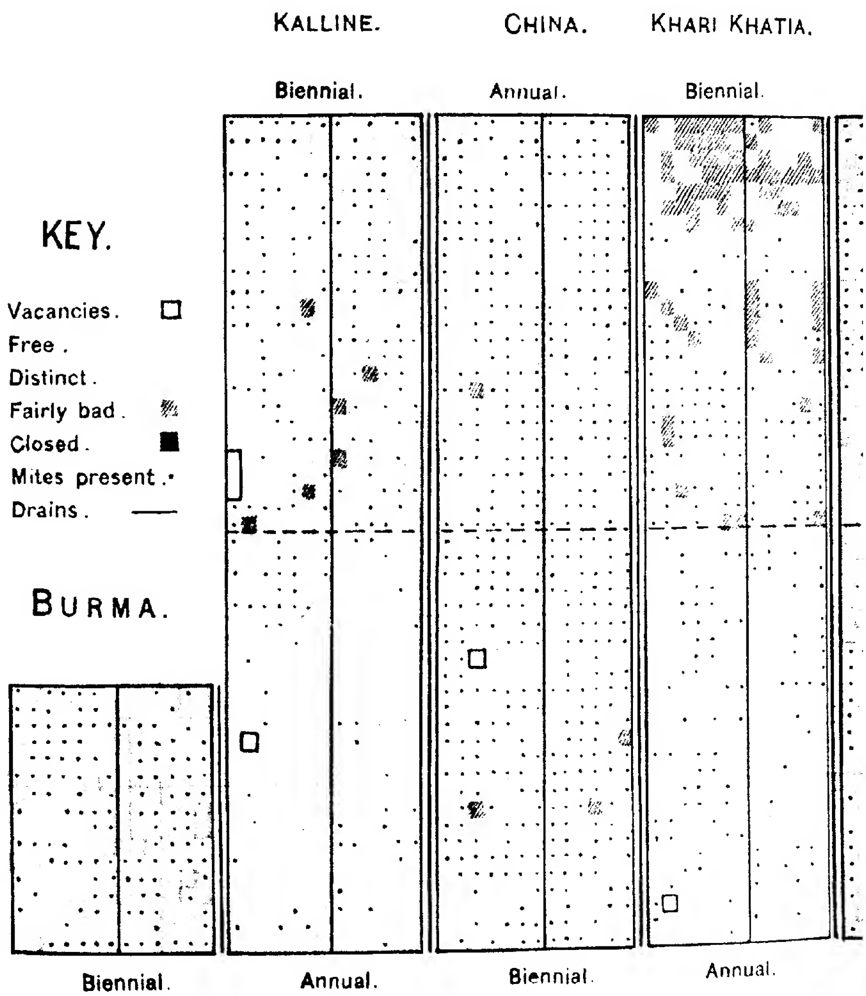

DIAGRAM 2

EFFECT OF SOIL TREATMENT
ON
RED SPIDER
1925

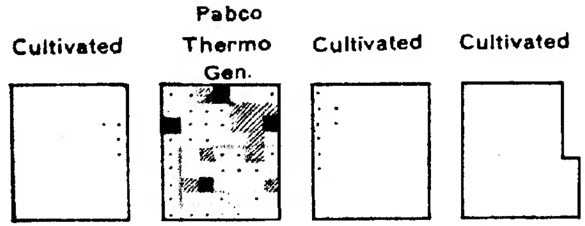

DIAGRAM 3.

1926

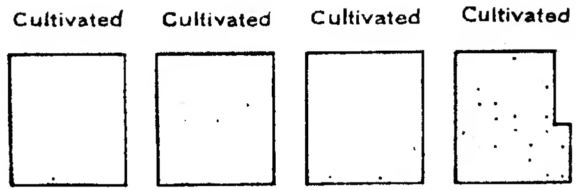

DIAGRAM 4.

recommended, although such proprietary insecticides as Clensel, Solomia, etc., have a somewhat greater killing power.

Sufficient has been published in recent numbers of this Journal to dispense with the necessity for going into detail as regards lime-sulphur spraying in this place. Suffice it to say, that the ideal treatment would be—

1. To spray or swab the bushes thoroughly with the insecticide at cold weather strength directly after pruning,

plus.

2. A spraying with the more dilute solution recommended for application to foliage directly red spider begins to show up,

plus.

3. A second spraying with the same solution five days later.

Few planters are in a position to do this. If it be only possible to do part of the area in the cold weather, the middle and heavy pruned tea should be the first to receive attention, so that if any be missed it will be the high-pruned tea, which can be sprayed when the pest appears.

There are other factors concerned with the incidence and control of red spider, such as, for example, its connection with soil acidity, on which certain observations have been made, but these have not as yet gone far enough to allow of any comment.

Much remains to be discovered, but it is hoped that this short sketch will present the main features of the red spider problem in such a way as to assist the practical man in following a policy, suited to his own conditions, most likely to conduce to a reduction in the damage done by the pest.

VEGETABLE PARASITES OF THE TEA PLANT.

(continued.)

BY

A. C. TUNSTALL.

Blights on the Stem *(continued.)*

Marasmius sarmentosus= *M. equicrinis.*

HORSE HAIR BLIGHT.

Refs. :—Watt & Mann, " The Pests & Blights of the Tea Plant," 2nd. ed., p. 410.

Petch, "Diseases of the Tea Bush," p. 83.

Indian Tea Association, "Quarterly Journal," 1925, Part I, p. 38.

Found in Jalpaiguri, Dooars, Assam and Cachar.

History :—The disease has been occasionally referred to in various publications since 1900.

Description :—The bushes are covered with festoons of black cords resembling horse hair. These cords which are mycelial threads of the fungus may develop from any portion of the bush. Unlike Thread blight the threads of this blight are not attached over their whole length but they are attached at intervals at points on the stem and the leaf. Occasionally the threads go right through dead twigs. Its fructification on tea in North-East India is rare.

Depredations :—This blight is fairly common on the bark of bushes attacked by other stem diseases. As a rule it merely feeds on the bark but on occasion it may penetrate the living tissues. Very little damage is done by this disease.

Septobasidium Sp.

BLUE VELVET BLIGHT.

Refs :—Petch, "Diseases of the Tea Bush," p. 114.

Indian Tea Association, "Quarterly Journal," 1923, Part II, p. 88.

Found in Darjeeling.

History :—The blight was fairly common in Darjeeling in 1911. It is now only found occasionally. The improvements in pruning and the introduction of spraying have reduced this and many other blights in recent years.

Description :—The fungus forms a bluish coloured velvety coating on the stems. This coating is a sheet of felt-like mycelium about 3 m.m. thick. The outer surface of this felt is dense and smooth while the internal layer is loose. No fructification has been observed yet. The fungus commences its life on the tea bush by attacking scale insects. When it has finished the scale insects it sets to work on the tea plant. It is wholly external and is frequently mistaken for *Rosellinia*. It is however an entirely different fungus.

Depredations :—As a rule this fungus merely feeds on the scale insect. Occasionally it may attack the tea plant but the damage done by it is not serious.

Remedies :—It is necessary to paint the branches first with 2 per cent. caustic soda solution. This loosens the fungus which may then be rubbed off a few days later. After removal of the fungus an application of Lime sulphur solution completes the treatment.

Septobasidium Sp.

BROWN VELVET BLIGHT.

Found in Assam and Dooars.

History :—This fungus is similar to that causing Blue Velvet blight. It was first noticed by the writer in 1912 and a few specimens are received from various parts of Assam and Dooars every year.

Description :—This fungus forms a deep brownish coloured velvety coating at the collar of the young plants. Sometimes it reaches the stem. The underground portion of the plant is covered by the fungus, where the mycellium ramifies to the feeding roots also. Below ground the fungus is similar in appearance to the Brown root rot (*Fomes lamaoensis*) externally, but internally the wood does not bear any brown streaks as is commonly found in

the case of roots attacked by the Brown root rot. The fungus generally does not penetrate the tissues of the stem and roots but on two occasions the root was observed to have been penetrated by the fungus, the cortex, medullary rays and the wood being attacked. The root produced abnormally prominent lenticels on its surface but there was no crust of sand and soil particles adhered to its surface.

The velvety coating on the aerial part of the bush has the same texture as that of the Blue Velvet blight and does not deviate much from it except in the colour of the fungus. No fructifications have yet been observed. As in the case of the Blue Velvet blight this fungus also commences its life on scale insects.

Depredations :—Very little damage is done by this fungus.

Remedies :—The same treatment as suggested for the Blue Velvet blight applies here also. But the dead plants should be dug out and burned.

STEM DISEASES IN WHICH THE PARASITE IS SECONDARY TO OTHER CAUSES.

I. STEM DISEASES DUE TO RESULT OF GENERAL DEBILITY.

Cephaleuros mycoidea, KART.

Cephaleuros parasiticus.

RED RUST.

Refs. :—Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 396.

Mann & Hutchinson, "Red rust," Indian Tea Association Pamphlet, No. 4, 1904.

Butler, "Fungi and Disease in Plants," p. 413.

Petch, "Diseases of the Tea Bush," p. 56.

Indian Tea Association, "Quarterly Journal," 1919, Part III, p. 90.

Indian Tea Association, "Notes on the Spraying of Tea," revised edition, 1925, p. 29.

Found in all districts in the plains in India.

History :—This disease is said to have attracted attention about 1880, when it was known as "White blight," a name which was given to it from the variegated appearance sometimes assumed by the leaves of the bushes attacked by this disease. The leaves bear green and white patches and in extreme cases the whole leaf may become white. This disease was very carefully worked out by Mann and Hutchinson and their observations were published in the Indian Tea Association pamphlet No. 4 of 1904. It is also present in Ceylon. Besides tea it is found on *Tephrosia candida* (Boga medeloa), Sau trees and many other plants.

Description :—Unlike the other diseases of tea, Red rust is caused by an alga. Many sea weeds and most of the slimy hair-like plants found in streams and ponds belong to the same class. Very few of them are parasitic like Red rust. The name Red rust is given from the appearance which the patches on the leaves and twigs assume when the fructifications of the alga develop. These fructifications are small red pin-like structures. But from a mycological point of view this name is unfortunate as a group of fungi which frequently attack cereals is commonly known by the same name.

Red rust lives in a number of forms. On the leaf it may live as an epiphyte or sometimes a parasite. Red hairy spots are noticed on leaves in shady places which sometimes go right through the leaf but in many cases are merely superficial. Sometimes the alga goes into partnership with fungus and forms grey spots. The leaf form can be found throughout the year in an active form. There is some evidence to suggest that the purely epiphytic form is a different species from the one which attacks the tissues.

When the alga penetrates the tissue of the leaf, it causes a small, purple, translucent spot on the upper surface of the leaf which extends through the leaf to the undersurface and assumes a similar but dirty appearance. The spot on the upper surface is generally raised above the leaf surface and the surrounding leaf tissue becomes dark thus forming a dark or purplish red margin. When old the fructifications of the alga develop at the centre of

the spot on both the surfaces. Ultimately the spot becomes dry and its central portion becomes grey and falls off leaving a small hole.

On the stem the alga is ordinarily parasitic. But here it is only discernible in its characteristic form when the red fructifications develop during the early rains.

The spore enters the stem through the cracks in the newly forming bark on young hardening shoots. From this the alga spreads to the green shoots. Sometimes the green shoots are attacked in the manner similar to the leaf but not so conspicuously. Here scaly grey patches are formed.

The alga penetrates into the bark and kills the cells. Young wood almost invariably dies but the old wood may recover. The fructifications are present in the early rains and sometimes on the old wood, in the cold weather.

The fructifications may develop in two ways. In one case the terminal cell of the thallus or the algal body becomes swollen and a sporangium or spore case is formed. This sporangium contains numerous spores each of which bears two cilia or hairs arising near together. These spores are called zoospores. In the second case vertical stalks arise at right angles to the surface to the thallus and are exposed to the air. The end cell of the stalk swells and from it arise a number of sporangia on curved pedicels. Besides these stalks the hair-like sterile stalks also arise from the thallus in the same manner. When mature the zoospores are liberated through an opening of the sporangium. These spores can swim actively in water by means of the two cilia. After a time they come to rest, germinate and give rise to a thallus. Germination only occurs in water.

The sporangia are easily blown about and may be distributed by wind, or they may be carried from leaf to leaf or from leaf to stem with drops of water.

Under normal healthy conditions the alga does not attack the tea stems, but if for any reason the vitality of the plant is impaired it becomes a serious parasite.

The conditions most likely to cause Red rust is lack of aeration of the soil. Hard pan, water-logging and a bad physical condition all do this. One of the effects of hard pan and water-logging is the production of shallow roots and if a drought occurs it is of course the shallow rooted plants that suffer first. Deficiency in some important soil constituent is also a contributing cause of this disease.

Any system of pruning which leads to the formation of weak twiggy wood is dangerous in point of view of Red rust. Plucking too close will also lead to thin weak wood, especially if carried out early in the season.

Depredations :—Now-a-days under ordinary circumstances Red rust does not do sufficient damage to warrant special treatment as attention is paid to all the above-mentioned points from the point of view of the yield of the bushes apart from their liability to diseases. There are occasions however when abnormal conditions bring about severe attacks of the disease and active measures are necessary to prevent a continuance of the attacks. Sometimes also new clearances and nurseries get badly attacked.

Remedies :—The first thing to do in the case of this disease will be to find out the contributing causes. If the conditions are improved in most cases this alone will be sufficient to prevent serious loss. It is however sometimes necessary to attack the disease directly. First of all the badly diseased young wood of the bush must be cut out. Such wood may survive for some time but it almost invariably dies back. The older wood may appear to be unattacked but closer examination generally reveals the presence of the disease. Fortunately on the old wood the alga is generally in the surface layers and spraying will check its growth.

In the case of very severe attacks and on young plants one cannot afford to wait until the cold weather and the treatment should be carried out at once. However, it is rarely necessary to carry out the pruning and spraying in the rains though it would be advantageous to do so if possible. In most cases labour would not be available and this treatment must be postponed. The

immediate application of the manures suggested below would in many cases help to keep the disease in check. The dead twigs should be cleaned out and the bushes sprayed thoroughly with one of the fungicides recommended. For cold weather work the most satisfactory fluid is Lime sulphur solution (see Spraying Pamphlet) but for rains' applications Burgundy mixture with the addition of a special adhesive mixture would probably be more satisfactory, although many planters consider Lime sulphur solution just as good. It should be noticed that the fruiting patches being hairy are difficult to wet and better results are obtained from spraying in the dry weather when the alga is not fruiting unless some special mixture is used.

Where the soil is poor the application of a little soluble manure just before the spraying will help the bushes along. The following mixtures might be tried :—

For sandy soil—		
Ammonium sulphate	...	1 cwt.
Superphosphate	...	1 ,,
Potassium nitrate	...	½ ,,
Stiff soil—		
Potassium nitrate	...	1 cwt.
Basic slag	...	1 ,,

To summarise—

1. Cut out all badly diseased wood.
2. Manure with stimulating manure.
3. Spray the bushes.
4. Arrange to remedy any defects of soil or pruning as soon as possible.

Glomerella cingulata. STONEM.

SEE BROWN BLIGHT, p. 81, Part III, 1927.

The fungus which causes Brown blight of the leaves also attacks the stems. In the Dooars, particularly, on areas which are susceptible to mosquito blight this disease is very prevalent. At first it was thought that the spores of the fungus concerned

were distributed by the mosquito bug and that infection took place at the insect puncture. The insects were found to carry the spores in large numbers but examination of large numbers of punctures in various stages failed to reveal a single case of infection. In the course of the investigation it was noticed that in some instances where tea was supposed to be badly damaged by mosquito the punctures were often difficult to find. The damage was not due to mosquito but to the Brown blight fungus and Red rust. These diseases were treated with remarkable results by spraying with Lime sulphur solution.

2. Stem Diseases due to special conditions.

Dead Snags.

No fungi are specially referred to under this heading because the fungi concerned are chiefly saprophytes or at the most very weak parasites. The cause of the death of the snags in most cases is not infection by parasites but the inability of the branch in question to maintain itself. Very frequently branches are found to be dead without being infected by fungi. This is particularly noticeable when the cuts have been carefully made and the wounds protected by tar or other preservative paint. In spite of this care some of the branches die and microscopic examination fails to show the presence of any fungi. The fungi which sooner or later attack such branches have nothing to do with their death. No amount of care to exclude fungi from such branches will prevent their death. Dead branches of this kind are particularly common on old tea after cutting back. They are more frequently found on tea growing in districts subject to long periods of drought. It is noticed that even in those districts when the tea in question has been well manured before cutting back the number of branches which die back is considerably reduced. If these dead branches are allowed to remain on the bushes they sooner or later become infected by fungi and bacteria. They then rot away. The organisms concerned very slowly kill the adjoining, previously healthy, tissues and a hole is formed. In the course of time if the decaying material is not cut right out the whole of the bush may become hollow.

By careful observation of sections which have previously been cut back it is possible to ascertain which branches are likely to die back and care may be taken to remove such branches when cutting back other sections. It is impossible to make any hard and fast rule applicable to all gardens. It is necessary for the planter to make his own observations on the garden concerned and act accordingly.

So far only one kind of dead snag has been mentioned. There is another kind directly due to the infection of the wood exposed by pruning. In dry districts or when the weather is very dry at the time of pruning a layer of the exposed wood is frequently dried up. In the subsequent wet period this dead wood becomes infected by weakly parasitic fungi which gradually extend their operations to the living wood causing a hole which often in the course of time extends right down the branch. In the districts with a damp cold weather this kind of snag, though not so prevalent, is still fairly common. Such snags may be found on healthy vigorous bushes growing under good conditions. In such a case the holes do not develop rapidly and it may be many years before any serious damage is done. It is therefore possible, usually, to cut out the diseased portion before this occurs.

It is certainly possible to prevent for a time the entry of the fungi associated with this form of decay by protecting the wounds in various ways. No protection, however, seems to be efficient for more than two years. In the case of small wounds this is quite sufficient as by that time callus will have covered them completely. When the wounds are large however this is important. After a year or two cracks develop in the wood and the protecting coat is rendered useless if it be very thin. If it be thick it generally peels off or blisters. Repainting does not overcome the difficulty as it is difficult to fill up the narrow cracks which are in many cases already infected. At the present state of our knowledge efficient protection of large wounds would seem to be impossible.

In spite of the difficulties the amount of dead snags to be found in all the tea districts is very much less than formerly,

This improvement has been brought about by better methods of pruning and better preparation of the bushes by manuring, resting, etc., before and after heavy pruning. It is however obvious that efficient protection of the large pruning cuts is very desirable and many observations have been made on various methods of treatment. The oldest method employed in the Indian Tea Districts is painting with tar. Thin wood tar was found to be more satisfactory than thick coal tar as the latter peeled off very readily. From time to time modifications of the process such as coal tar mixed with kerosine and coal tar with lime have been tried and abandoned. Oil paints of various kinds have also proved failures.

The most satisfactory treatment so far discovered is as follows :—

Dissolve 4 lbs. of copper sulphate in 1 gallon of water. (To dissolve this amount readily the copper sulphate should be powdered and enclosed in a bag which should be suspended in hot water.) Dissolve an equal weight of washing soda or half the weight of soda ash in the same quantity of water. Mix the two solutions when cold in a large vessel. Sometimes a vigorous effervescence takes place hence the need of a large mixing vessel.

This however is disappointing for while it prevents the decay of the exposed wood for a considerable time it certainly hinders the growth of callus.

More recently a paste made by mixing fresh cattle manure with sulphur has been tried but although callus growth is stimulated it is too early to say whether it will prevent the decay of large wounds long enough to enable them to heal satisfactorily.

At present whenever old wood on a tea bush is cut it is impossible to avoid a certain amount of decay. By careful management however much can be avoided.

1. All tea which it is intended to cut back should be well manured and cultivated for at least a year before the operation takes place.

2. It is necessary to ascertain by observation on the particular garden concerned the branches which are likely to die back after cutting back. These should not be allowed to remain.

3. Great care should be taken to make the cuts as smooth as possible—no projecting edges should be left.

4. The larger wounds should be protected by painting them.

5. Ample growth should be allowed on cut back bushes. In some cases where the cut back tea is in poor condition it is desirable to leave it unplucked for a full year after cutting back. This is much better than leaving it unpruned at the end of the first year.

6. In the cold weather following the cutting back the bushes should be gone over carefully. Any dead wood or rotting wounds should be pruned out and the wounds painted. It is advisable at the same time to repaint old wounds which have not healed over.

It should be remembered that the more vigorous the plant is the more quickly the callus grows over wounds.

Dead snags could be almost entirely avoided if a system of pruning were evolved which would eliminate the necessity for cutting old wood. Considerable attention has been paid to this in recent years but it is too early to say whether it can be done satisfactorily.

CANKER.

Another disease of stems which does not appear to be directly due to vegetable parasites is the condition known as canker. The young wood swells irregularly thus presenting a cankerous appearance. This condition is frequently associated with severe attacks by insects such as the "mosquito" bug. In the early stages there does not appear to be any infection but later, the Red rust alga, Brown blight and Grey blight fungi are often formed on the damaged stems. The condition is most commonly observed when vigorous tea, which has been cut back in the previous cold weather, is severely attacked by mosquito blight in July or

August. The cankerous appearance is noticeable by October or November and by the end of the cold weather many of the affected branches are badly attacked by red rust.

Experience has shown that it is desirable to cut out branches of this kind. If they are left in the bush they subsequently die back.

It is also desirable to spray the section concerned with Lime sulphur solution after pruning.

Cankerous wood similar in external appearance to that described above is also produced by fungal infection. *Nectria cinnabarina* has occasionally been found in such wood but it should be pointed out that as a general rule this fungus does not produce cankers on tea.

As there is a possibility of mistaking the infected stems for uninfected ones it is wise to send specimens to Tocklai whenever such outbreaks occur.

PROPOSED TOURING PROGRAMME OF THE OFFICERS

OF

THE SCIENTIFIC DEPARTMENT.

Season 1928.

Months.	P. H. Carpenter.	H. R. Cooper.	C. R. Harler.	C. J. Harrison.
January ...	......	......	......	N. Lakhimpur.
February ...	......	Dhunsiri and Golaghat.	......	......
March ...	Calcutta ...	Chutla Bheel and Hailakandi.	Dooars ...	......
April ...	North and North west Cachar	HOME LEAVE	......	......
May ...	North Surma		Sonari ...	......
June ...	......		......	Lakhipur.
July ...	Calcutta		Balisera and Luskerpore	......
August ...	Mangaldai		......	......
September ...	......		......	......
October ...	......	......	......	......
November ...	Calcutta ...	......	......	......
December ...	......	......	......	......

The other Officers of the Department will tour as their investigations necessitate.

The exact dates of the above tours will be given later to the Sub-District Chairmen. Managers desiring a visit from the Scientific Officer must inform the Sub-District Chairman who will make out a tour itinerary.

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